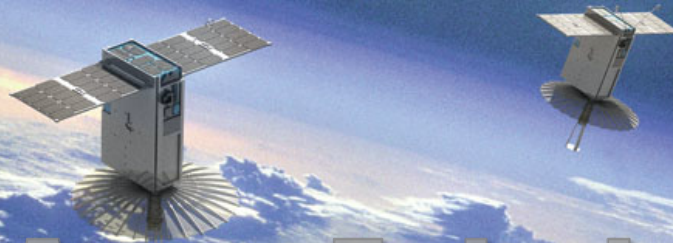




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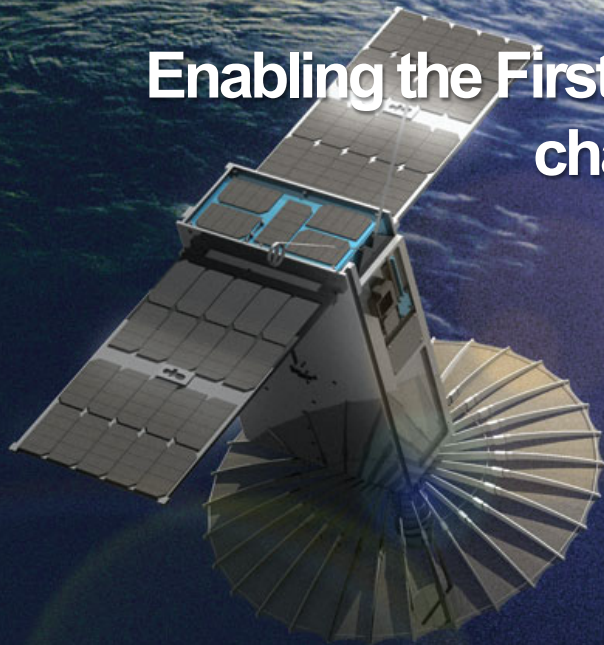


Antenna Technologies

Enabling the First Active Radar in a CubeSat with Game-changing Antenna Technology: Raincube

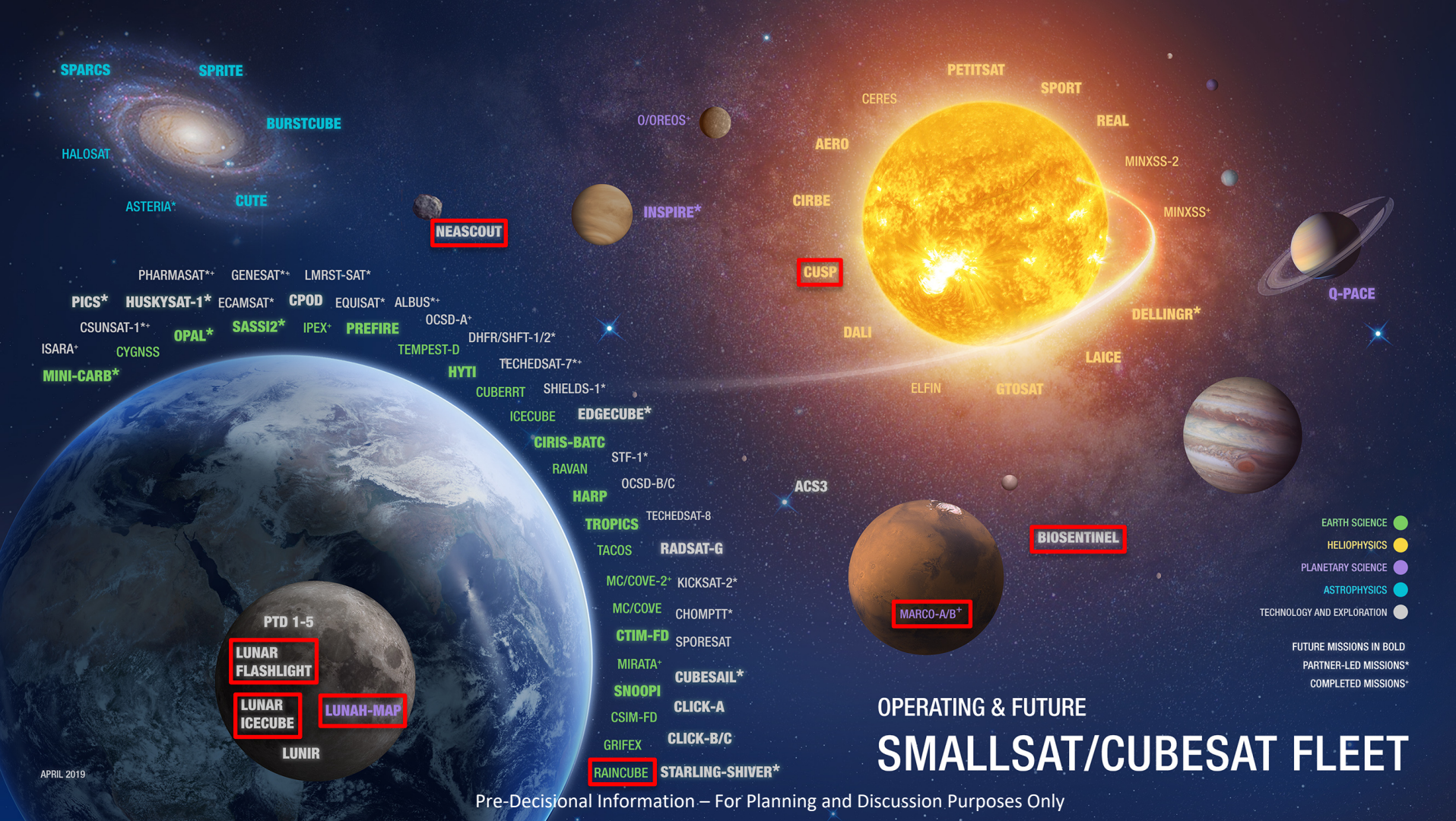
Nacer Chahat

Mechanical Engineers: Jonathan Sauder and Mark Thomson

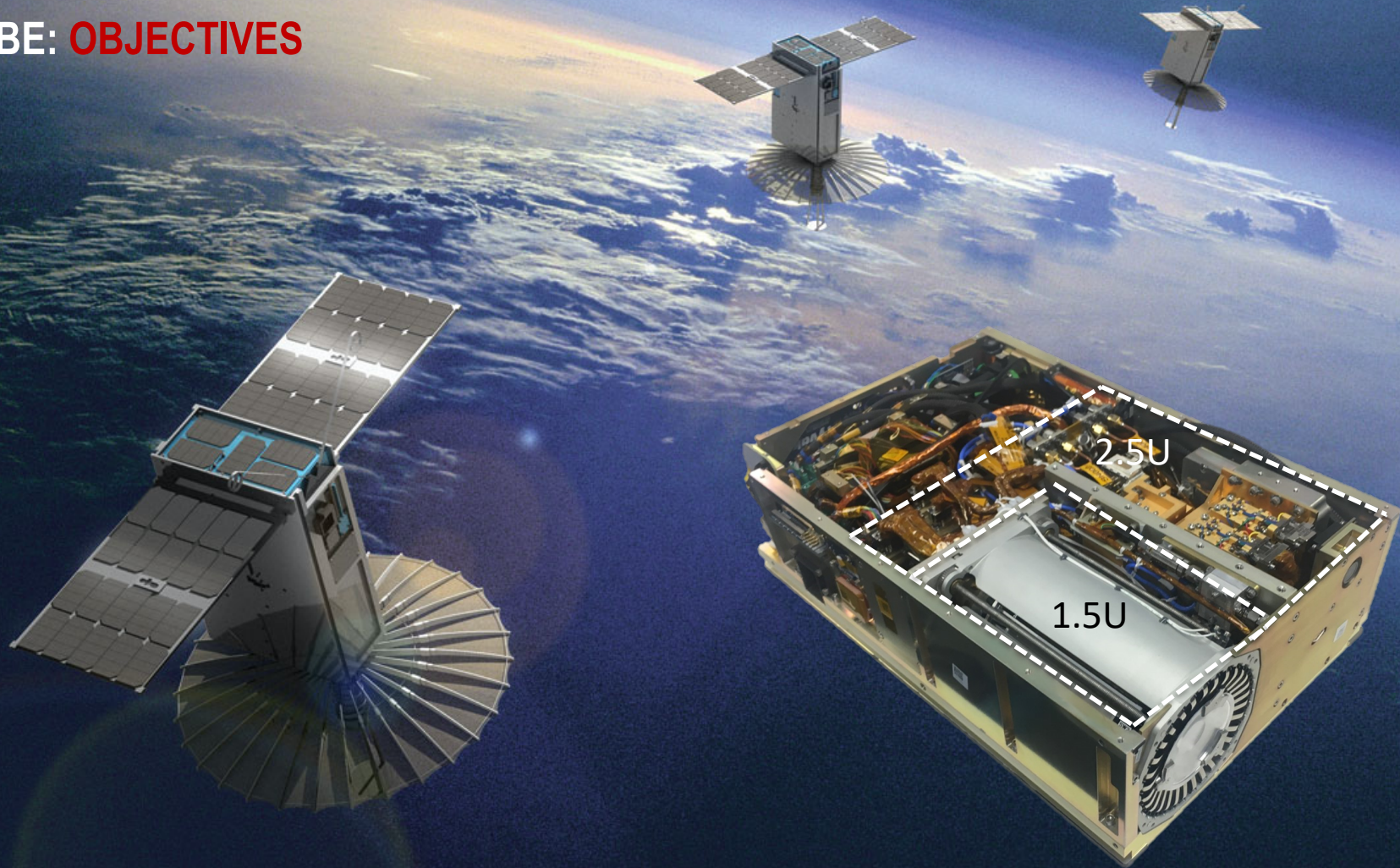


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Pre-Decisional Information – For Planning and Discussion Purposes Only



RAINCUBE: OBJECTIVES



Pre-Decisional Information – For Planning and Discussion Purposes Only

RainCube: Radar in a CubeSat

- 0.5-m reflector Ka-band antenna
- Polarization: V-polarization
- Gain: 42.6 dBi
- Efficiency: 56%
- HPBW: **$0.57^\circ \rightarrow$ footprint = 8.0km**
- Key RF innovation:
 - Compensation of the non parabolic shape
 - Telescoping waveguide
 - 40 opening per inch (OPI) mesh reflector
 - Capability of modeling accurately the Ka-band antenna including the shape distortion and OPI

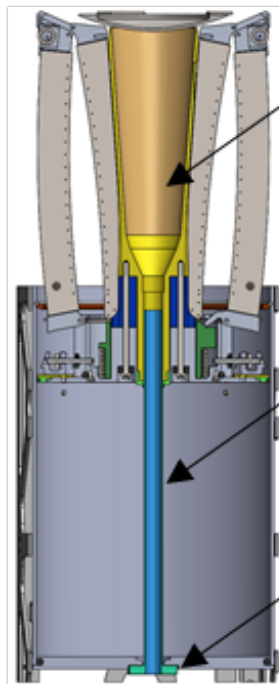
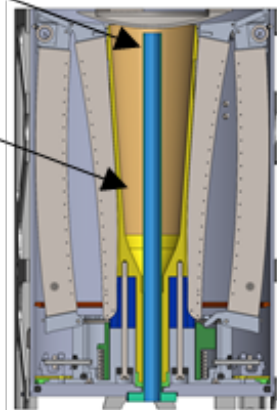


RainCube: Radar in a CubeSat

- 0.5m mesh reflector
- Gain: 46dBi
- Efficiency: 56%

Telescoping
waveguide

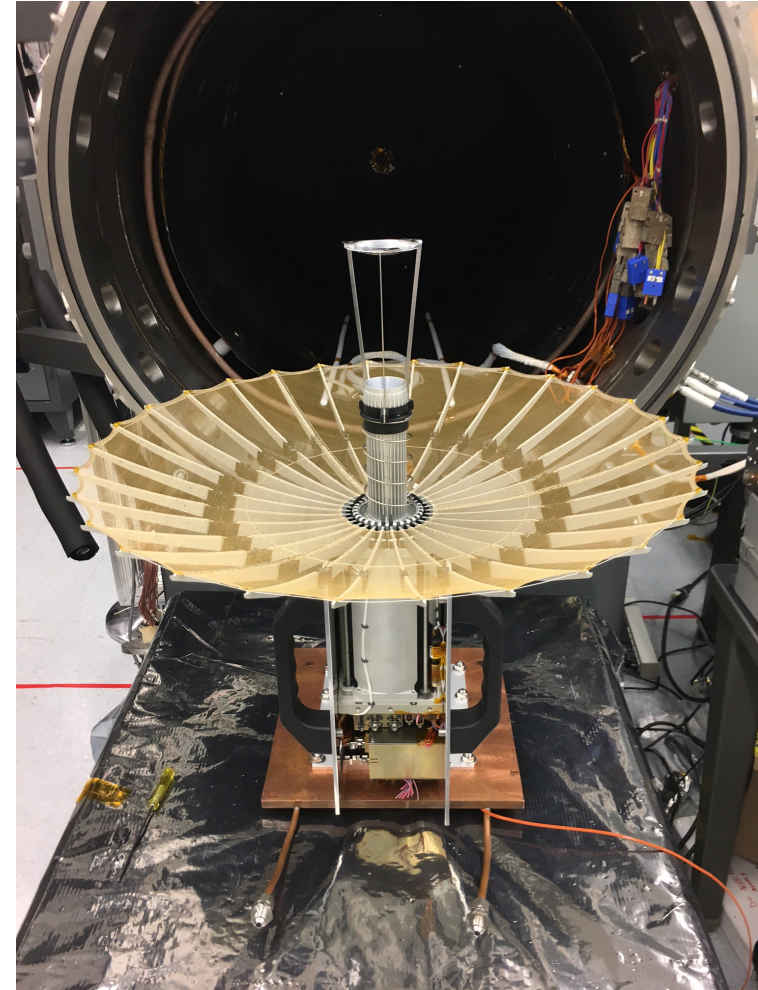
Multiflare
horn



Multiflare
horn

Telescoping
waveguide

Rect.-to-Circ.
waveguide
transition



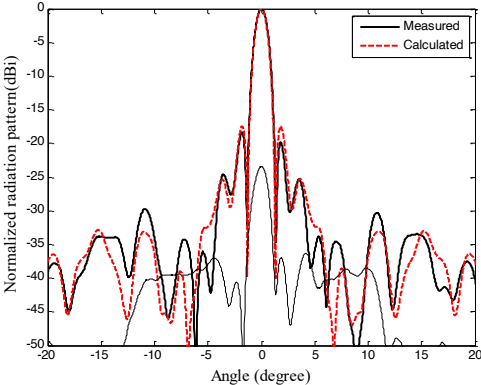
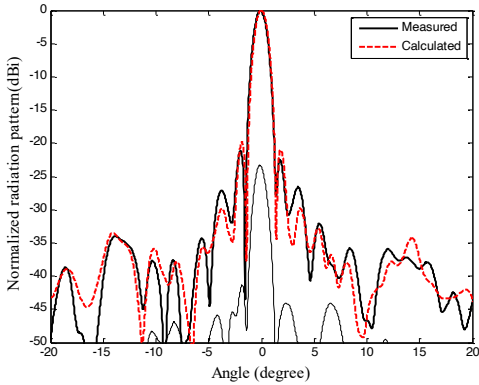
N. Chahat, *et al.*, "CubeSat Deployable Ka-Band Mesh Reflector Antenna Development for Earth Science Missions," *IEEE Trans. Antennas & Propag.*, vol. 64, no. 6, pp. 2083-2093, June 2016.



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RainCube: Radar in a CubeSat

- Antenna description:



	Directivity (dBi)		Gain (dBi)		Loss (dB)*		Peak SLL (dB)	
	Calc.	Meas.	Calc.	Meas.	Calc.	Meas.	Calc.	Meas.
Solid	43.6	43.55	43.3	43.24	0.3	0.31	-17.45	-17.75
Mesh	-	43.28	42.61	42.48	-	0.8	-16.8	-18.33

N. Chahat, et al., "CubeSat Deployable Ka-Band Mesh Reflector Antenna Development for Earth Science Missions," *IEEE Trans. Antennas & Propag.*, vol. 64, no. 6, pp. 2083-2093, June 2016.



RainCube: Access to Space

- Launched on May 20th 2018
- Soft Cargo on ISS resupply
- Deployed from ISS via NanoRacks in July
- Antenna deployed 4 weeks into commissioning

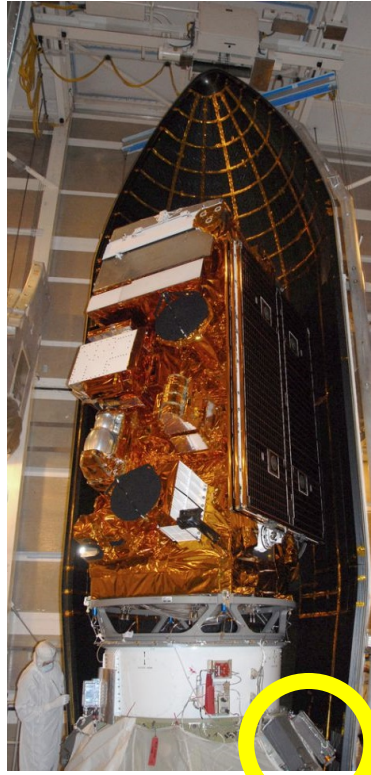
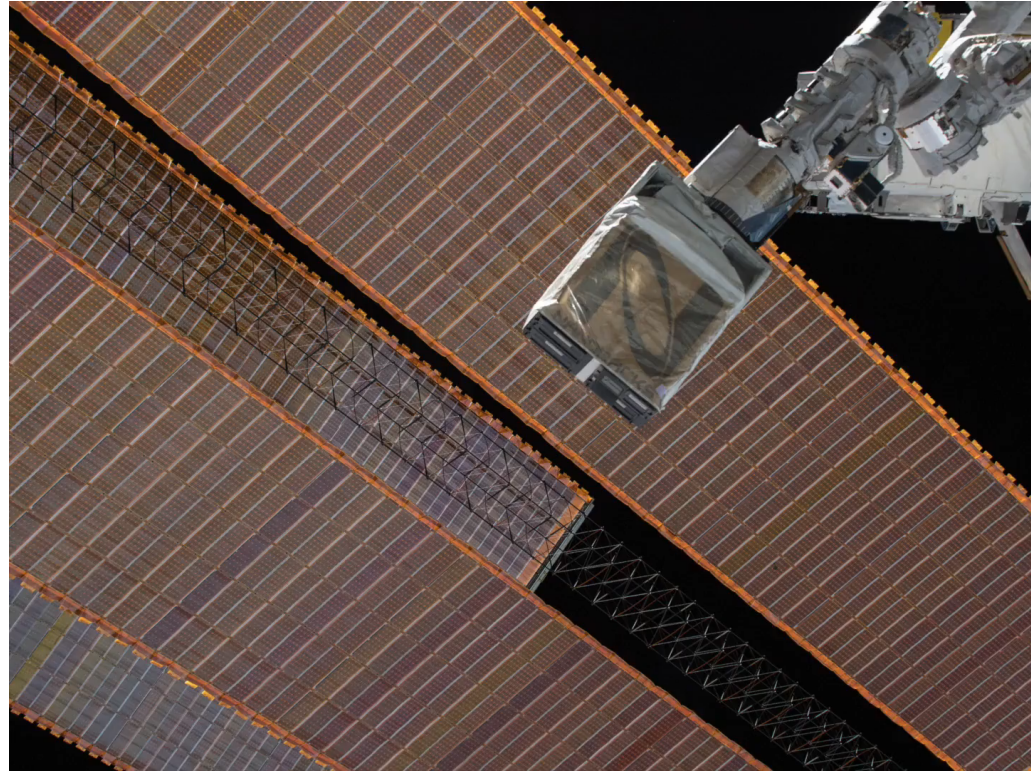
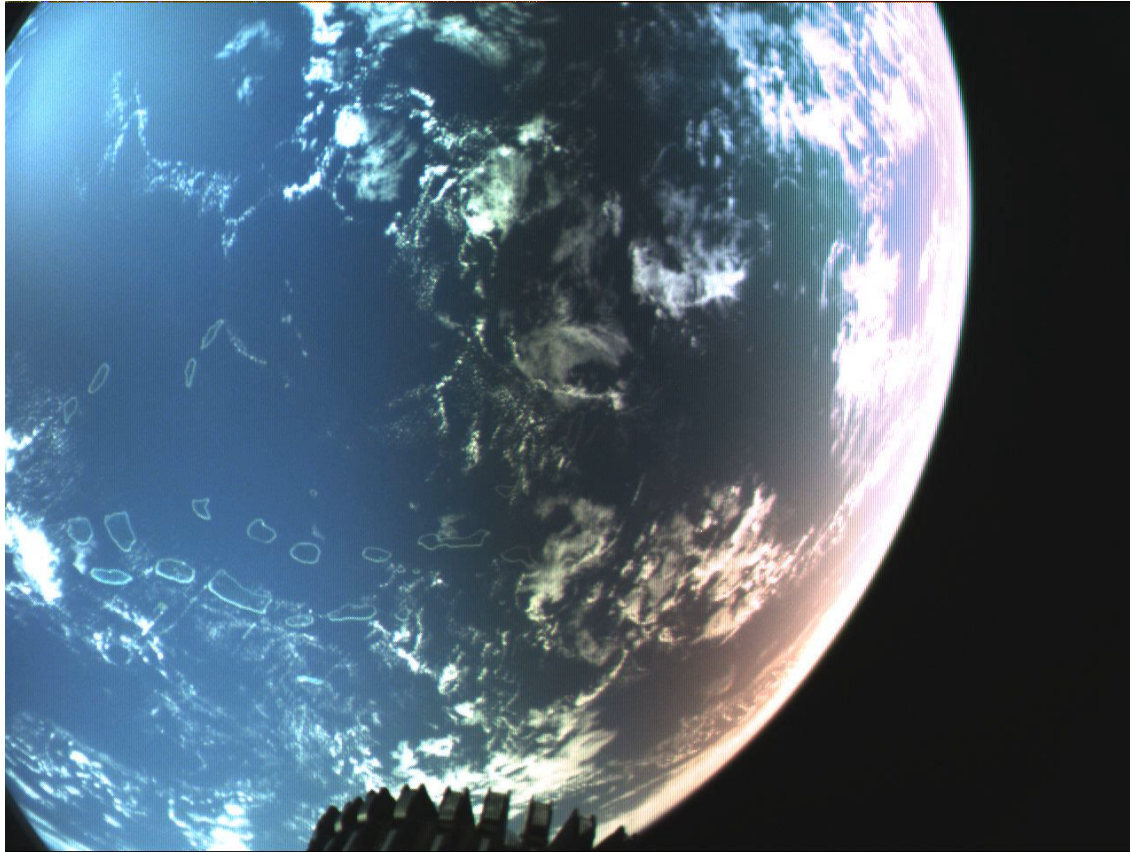


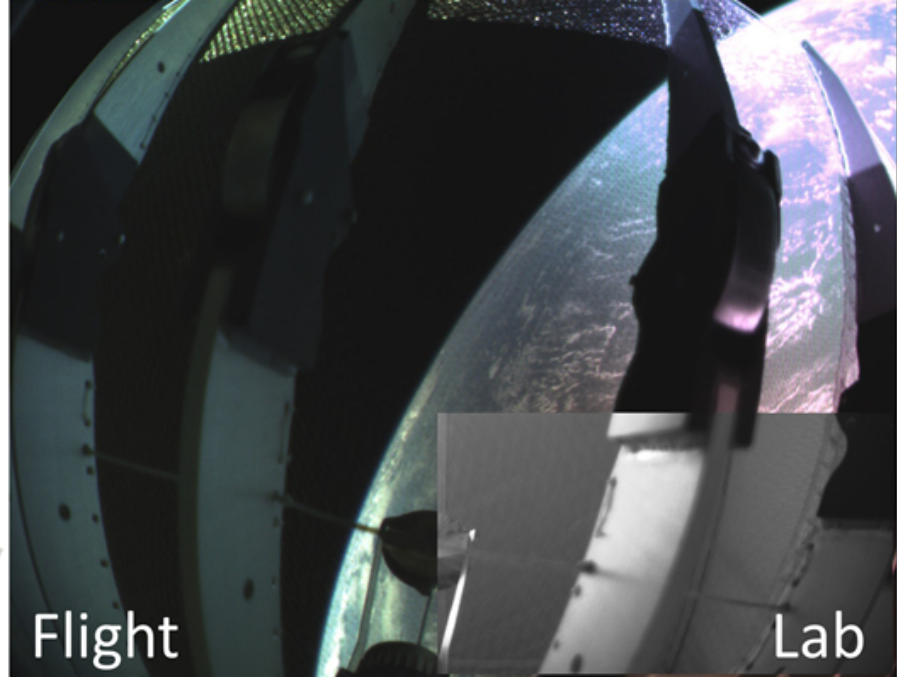
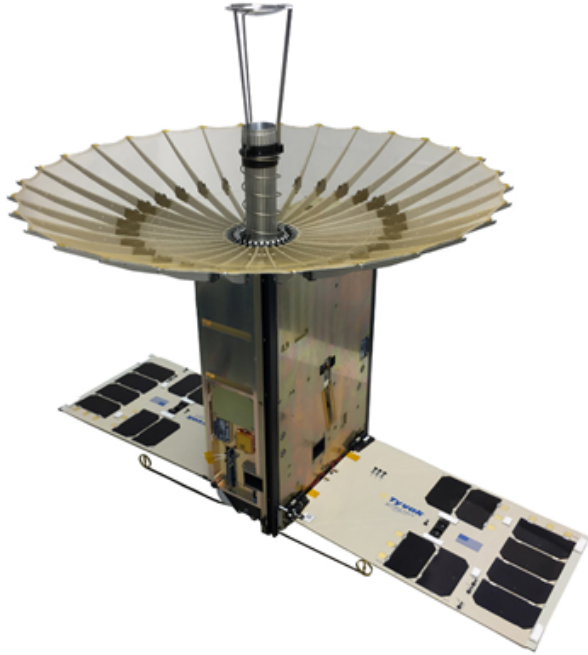
Image Credit: NASA/ Mark P. Mackley, VAFB



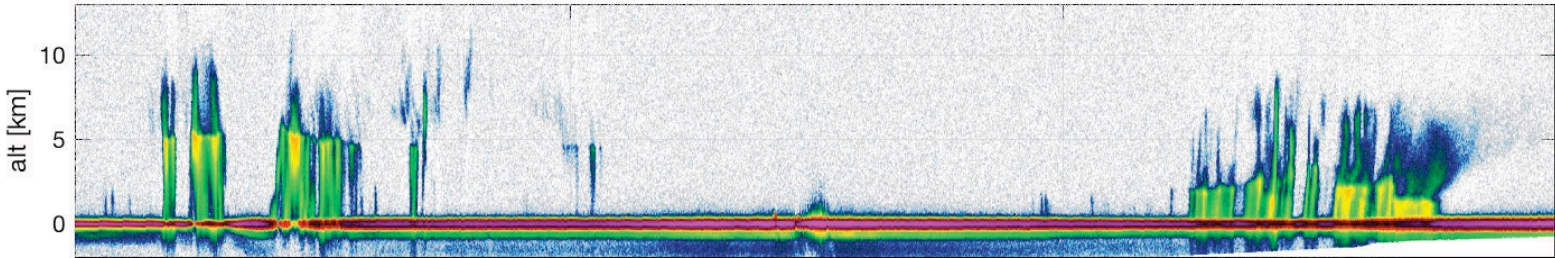
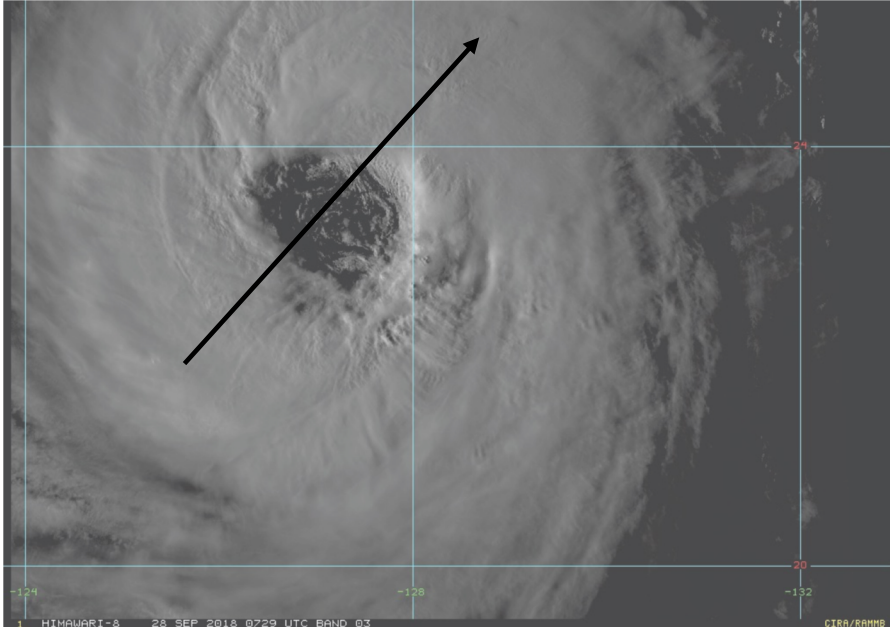
RAINCUBE: Deployment in Space



RAINCUBE: Deployment in Space



RainCube: Science Collected



RainCube: Collaborative Measurement

RainCube and TEMPEST-D observed Trami 5 minutes apart

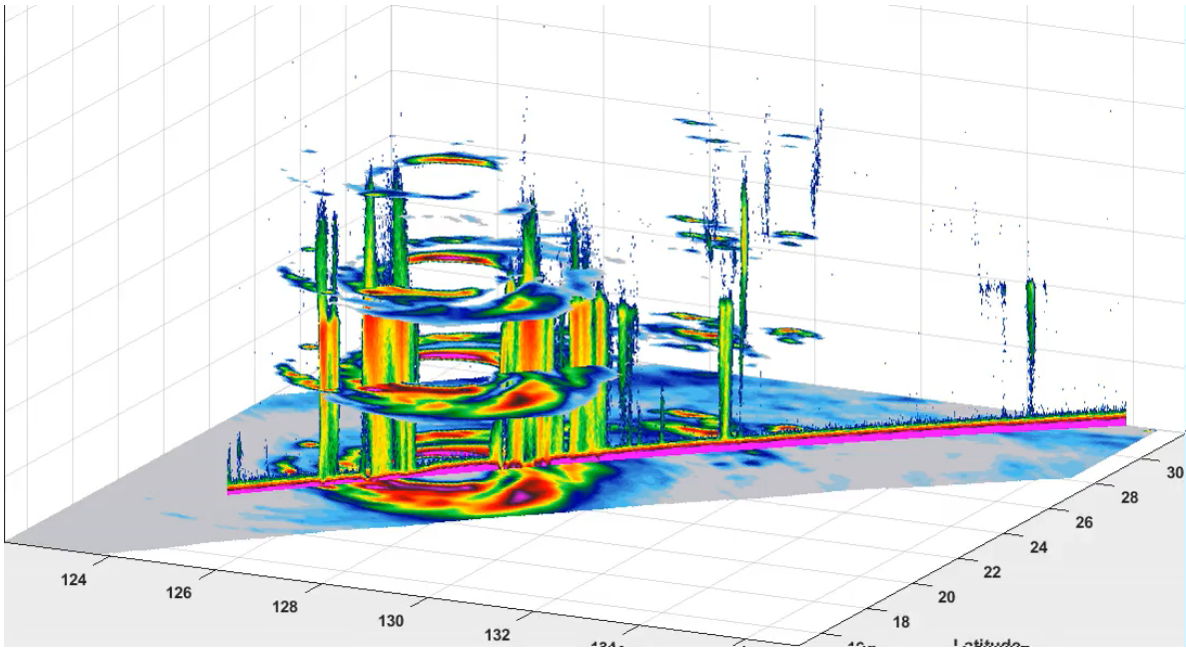
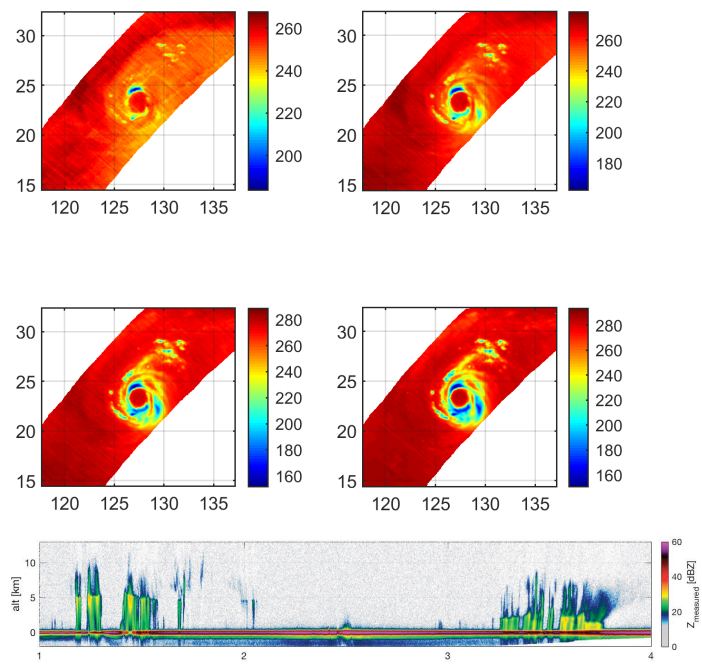
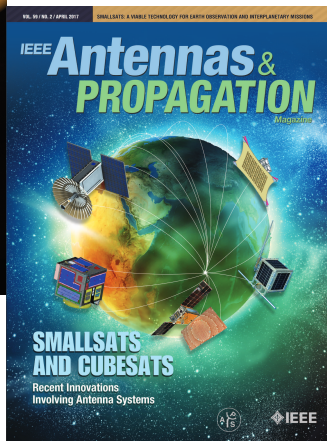


Image Credit: S. Brown/RainCube and TEMPEST-D teams

JPL Antenna Technologies in IEEE



N. Chahat, “A mighty antenna from a tiny CubeSat grows,” *IEEE Spectrum*, vol. 55, no. 2, pp. 32-37, Jan. 2018.



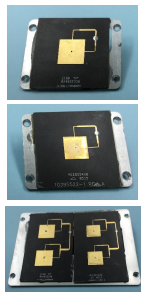
N. Chahat *et al.*, “Deep Space Network Telecommunication CubeSat Antenna: Using the deployable Ka-band mesh reflector antenna,” *IEEE Antenna Propag. Magazine*, vol. 4, April 2016.

N. Chahat *et al.*, A Review of CubeSat Antennas: From Low Earth Orbit to Deep Space, accepted to *IEEE Antennas and Propagation Magazine*.

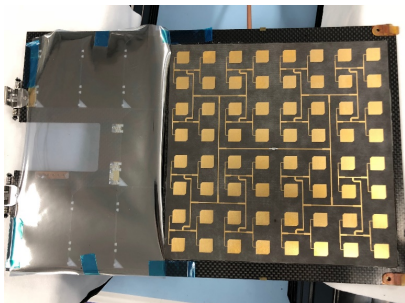
Book to be published in JPL Descanso Book Series – Wiley IEEE.

N. Chahat, “CubeSat antennas for Earth Science and interplanetary missions

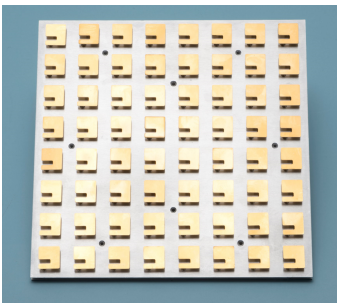
Antennas for CubeSats



X-band LGA



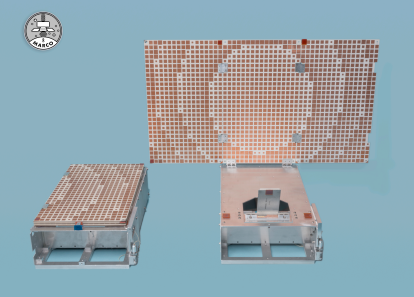
X-band MGA



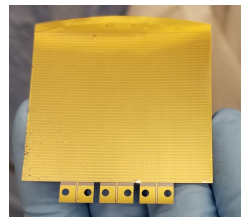
All-metal Tx/Rx HGA



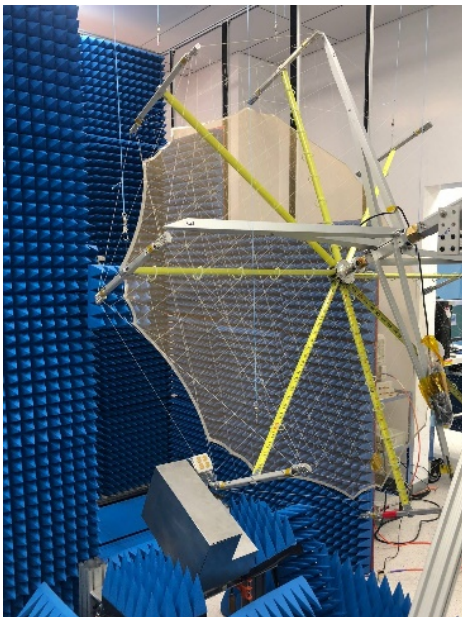
Ka-band all-metal metasurface



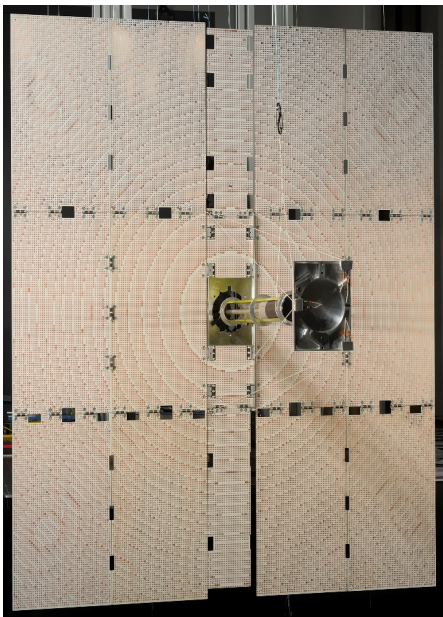
MarCO HGA



W-band beam steering metasurface



X/Ka 1m-mesh reflector

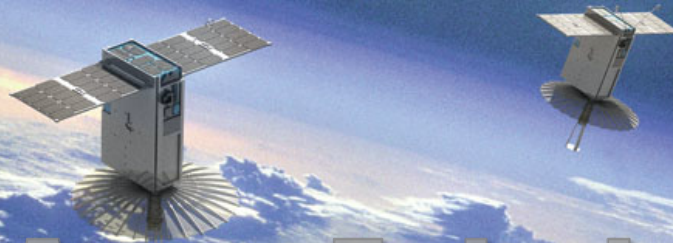


Ka-band 1m reflectarray

N. Chahat *et al.*, A Review of CubeSat Antennas: From Low Earth Orbit to Deep Space, accepted to *IEEE Antennas and Propagation Magazine*.



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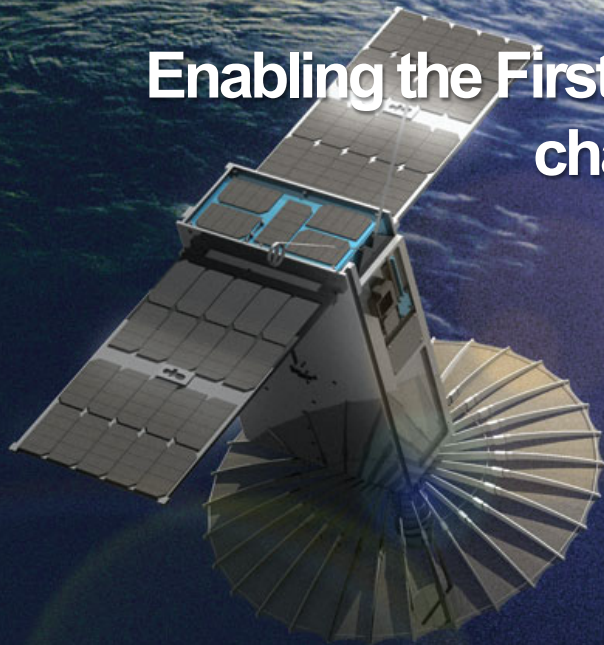


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